Sudden brightenings of HD 96273 or BD+07 2411B were observed with the HIPPARCOS satellite in 1992, which still require a convincing explanation. A new analysis of all known data of these two stars is given, including additional information on the Balmer line equivalent widths. The brightenings can be explained as SU UMa type dwarf nova outbursts, superimposed on the combined light of two normal F and G type main sequence stars. Since the hypothetical dwarf nova turns out to be located at the same distance as HD 96273 and BD+07 2411B, we possibly see here the first case of a cataclysmic variable as a member of a multiple star system. Questions on history and evolution, as well as possible ways to confirm this interpretation, are briefly outlined.

Key words. stars: cataclysmic variables – stars: dwarf novae – stars: individual: HD 96273 – stars: individual: BD+07 2411B – stars: individual: FH Leo

Astronomy & Astrophysics manuscript no. FH˙Leo˙tex.txt February 5, 2008
(DOI: will be inserted by hand later)

FH Leonis, the first dwarf nova member of a multiple star system?

Nikolaus Vogt[1],[2]

[1] Instituto de Astronomia, Universidad Catolica del Norte, Antofagasta, Chile
[2] Departamento de Fisica y Astronomia, Universidad de Valparaiso, Valparaiso, Chile

Received / Accepted

Abstract.

1. Introduction

A recent paper in this journal, by Dall et al. (2005, hereafter DSSI) was titled "Outbursts on normal stars – FH Leo misclassified as a novalike variable". The authors report three possible brightenings of the combined flux of the wide binary HD 96273 and BD+07 2411B observed with the HIPPARCOS satellite in 1992, January 3, January 15 and June 19 with amplitudes between $0^m.1$ and $0^m.35$ above the normal brightness level of this double star. They obtained high resolution spectra of both stellar components, determined their effective temperatures, surface gravities, microturbulence parameters, rotation and radial velocities as well as abundances of several chemical elements. Since both stars behave –according to all these parameters– like normal main sequence dwarfs, DSSI concluded that the identification as a cataclysmic variable must be wrong. They discussed several possible causes of the observed brightenings, in particular transient background or foreground objects, magnetic interaction with an unseen companion, a planetary accretion event and a microlensing event. Finally, they point out that none of these explanations seems to be convincing.

In this Research Note I would like to show that most of the observed properties of FH Leo can have their natural explanation if we assume that it is a dwarf nova at the same distance as HD 96273 and BD+07 2411B.

2. FH Leo as a dwarf nova companion of HD 96273 or BD+07 2411B

The HIPPARCOS distance of this binary is 117 pc. This implies an absolute magnitude $M_V = +3^m.6$ of HD 96273 and $M_V = +4^m.8$ of BD+07 2411B. The effective temperatures determined by DSSI correspond to spectral types F6V (HD96273) and G3V (BD+07 2411B). These absolute magnitude values and also the observed colours are in accordance with a classification of a normal main sequence star, the interstellar reddening can be neglected. The combined absolute magnitude in the blue spectral range is $M_B = 3^m.76$. Since on 1992, January 3 (JD 2448624) a brightening of $0^m.27$ on average was observed, the absolute magnitude of the total light during this event was $M_B = +3^m.49$. Therefore, the absolute magnitude of the brightening source alone is $M_{bs} = +5^m.13$, which is nearly identical of that of a dwarf nova at outburst maximum: equation (3.4) of Warner (1995) predicts a value between $+5^m.2$ and $+5^m.3$ for a dwarf nova with an orbital period between 1.5 and 2 hours. On 1992, January 15 (JD 244 8636) the absolute magnitude of the brightening source was $M_{bs} = +6^m.1$, about 1^m fainter than 12 days before. A natural explanation of this behaviour is that of an SU UMa type dwarf nova which begun its superoutburst in 1992, January 3 and declined slowly towards the end of its plateau phase in January 15. This way, even the differences of about $0^m.1$ between the brighter and the fainter magnitude measures in January 3 could be explained by the superhump activity; the brighter points may refer to the superhump peaks, their time difference is about 2 hours, compatible with the superhump period of a typical SU UMa type dwarf nova. The total intrinsic superhump amplitude would be of the order of $0^m.4$, just as expected during the early stage of a superoutburst.

One important question, however, remains, the absorption spectra of HD 96273 and BD+07 2411B look rather normal. In particular, DSSI did not find any traces of hydrogen emission which would be typical for dwarf novae in quiescence. For instance, Thorstensen et al. (2002) give Hγ emission equivalent widths of 40Å for V844 Her and 20Å for DI UMa. In Hβ even values up to 100Å are possible (Warner, 1995, Fig. 2.35). Indeed, the hydrogen emission may be present in FH Leo, but unobservable due to the large difference in brightness between HD 96273/BD+07

Send offprint requests to: N. Vogt, e-mail: `nvogt@ucn.cl`

2411B and the hypothetical dwarf nova in quiescence. If FH Leo is an SU UMa type dwarf nova with a long outburst cycle, similar to WX Cet (Sterken et al., 2006) we expect an amplitude $\geq 6^m$, revealing an absolute magnitude $\geq 11^m.1$ of the dwarf nova in quiescence. Because of the large difference in the continuum flux, even in the blue spectral range, an emission equivalent width of Hγ of 40Å of the quiescent dwarf nova would be reduced to a contribution of about 0.045Å in the equivalent widths of HD 96273 or BD+07 2411B while the above maximal EW value of Hβ would contribute 0.11ÅḊSSI did not publish their measured equivalent widths of these stars, but the authors kindly sent me an original spectrum of each star. From this I have determined the equivalent widths of Hα, Hβ, Hγ and Hδ. Their values are 3.7 ± 0.2, 5.9 ± 0.3, 7.4 ± 0.8 and 5.1 ± 0.3 resp. for HD 96273 and 3.0 ± 0.2, 3.6 ± 0.3, 5.5 ± 1.0 and 3.2 ± 0.2 resp. for BD+07 2411B (the given errors refer mainly to uncertainties in the continuum determination. An emission contribution of the dwarf nova in quiescence would reduce such equivalent widths by a very small amount ($\leq$2%) which certainly is impossible to recognize even in high resolution spectroscopy. Therefore, it is not surprising that DSSI did not find any anomaly in the spectra of HD 96273 and BD+07 2411B.

The brightening event of 1992, June 19 (JD 2448793), about 169 days after the "superoutburst" detection, could perhaps be explained as a short outburst of the dwarf nova. However, there are some other measurements without a significant brightening, only a few hours before and afterwards. Therefore, this event could also refer to a short-lived "flare" which also was observed in other dwarf novae (Bateson 1989). In any case, further observations will be necessary to confirm the existence of short eruptions or flares in FH Leo.

3. Conclusions

The most plausible explanation of the outburst behavior of FH Leo would be that of an SU UMa type dwarf nova, superimposed on the wide binary HD 96273 and BD+07 2411B, and placed at the same distance as this binary. If this is true we either have a very rare and improbable chance coincidence, or simply a gravitationally bound multiple star system with a dwarf nova orbiting HD 96273 or BD+07 2411B. To my knowledge, this would be the first case of the detection of a cataclysmic variable as component of a multiple star system. Rather interesting questions would arise concerning the possible evolutionary history of such a system: What is the age of it? What was its origin and how did it evolve? Since the HD 96273/BD+07 2411B system is a rather wide binary (projected physical separation 936 AU) there is plenty of space for hierarchical sub-structures of smaller dimensions, such as a giant-type progenitor of a cataclysmic variable which has to pass the subsequent common envelope phase.

This interpretation, however, needs to be confirmed. This can be done in different ways: First of all, we will monitor FH Leo in the next season closely and search for additional outbursts, which also should reveal superhumps, the main characteristic of any SU UMa type dwarf nova. This will be done in our Cerro Armazones Observatory (Universidad Catolica del Norte, Antofagasta) and possibly at other institutions. On the other hand, we will search for outbursts of FH Leo in the patrol plate archive of the Sonneberg Observatory, which is, following Harvard, the world-wide second largest in size and plate number (Braeuer and Fuhrmann 1992). It covers several decades beginning about 1930, and was used to detect more than 10000 new variable stars. The typical threshold of detection with blink comparator or similar visual inspection methods, as applied traditionally at the Sonneberg Observatory, is about $0^m.3$, just the total amplitude of FH Leo. Therefore, it is not surprising that FH Leo remained undetected until recently. New scanning and reduction methods as applied by Vogt et al. (2004), however, allow us to reduce this threshold to less than $0^m.1$, thus enabling the detection of historical outbursts of FH Leo. A search for them is in preparation.

4. Acknowledgements

I would like to thank Dr. Thomas H. Dall for kindly providing me the original spectra, and to Dr. Eduardo Unda-Sanzana for his assistance in the data treatment. I also acknowledge the support of FONDECYT (grant 1061199).

References

Bateson, F.M. 1989, Publ. Var. Star Sect., RASNZ 16, 75

Braeuer, H.-J. & Fuhrmann, B. 1992, Die Sterne 68, 19

Dall, T.H., Schmidtobreick, L., Santos, N.C., Israelian, G. 2005, A&A438, 317

Sterken, C., Vogt, N., Uemura, M., Tuvikene, T. 2006, PASP, submitted

Thorstensen, J.R., Patterson, J., Kemp, J., Vennes, S. 2002, PASP 114, 1108

Vogt, N., Kroll, P., Splittgerber, E., 2004, A&A428, 925

Warner, B. 1995, Cataclysmic Variable Stars, Cambridge University Press